

## CHAPTER 14

### DEMOGRAPHY AND EXTINCTION

*What are the minimum conditions for the long-term persistence and adaptation of a species or a population in a given place? This is one of the most difficult and challenging intellectual problems in conservation biology. Arguably, it is the quintessential issue in population biology, because it requires a prediction based on a synthesis of all the biotic and abiotic factors in the spatial-temporal continuum.*

Michael Soulé (1987)

A PREVIEW: How large is large enough?

As a general rule, an  $N_e$  of 50 is necessary in the short-term to prevent immediate harmful effects of inbreeding, and an  $N_e$  of about 500 is necessary to retain enough genetic variation in order to maintain long-term evolutionary potential.

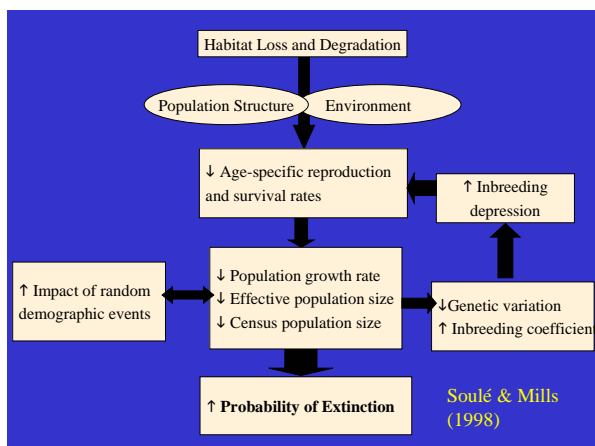
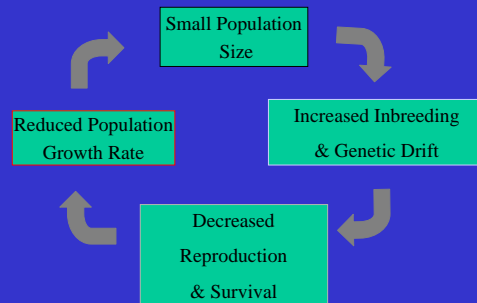
50/500 Rule

(Somewhat controversial)

### GENETICS AND POPULATION VIABILITY

- (1) Inbreeding depression
- (2) Loss of genetic and phenotypic variability
- (3) Loss of evolutionary potential
- (4) Effects of mtDNA
- (5) Mutational meltdown

### The Extinction Vortex



What is the evidence that genetic factors are important for the viability of populations?

Evidence for genetic rescue:

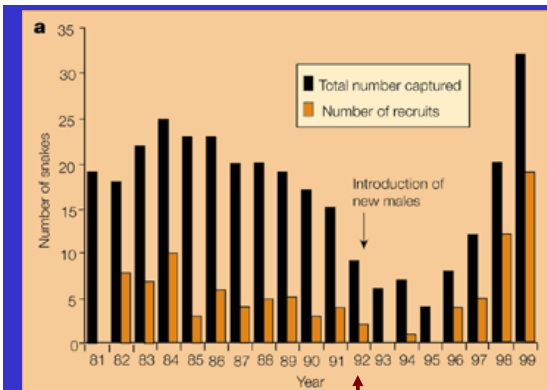
Adders in Sweden

Prairie chickens in the U.S.

Florida panthers

Conservation biology

## Restoration of an inbred adder population



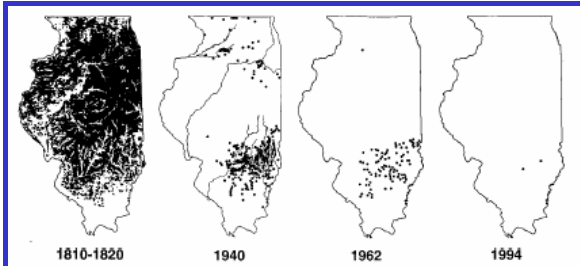
Introduction of males

## Tracking the Long-Term Decline and Recovery of an Isolated Population

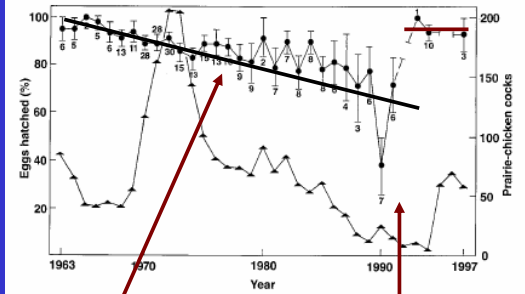
Ronald L. Westemeier,<sup>\*</sup> Jeffrey D. Brawn,<sup>†</sup> Scott A. Simpson,  
Terry L. Esker, Roger W. Jansen, Jeffery W. Walk,  
Eric L. Kershner, Juan L. Bouzat, Ken N. Paige



Greater prairie chicken



Loss of prairies in Illinois from 1810-1994



Egg hatchability

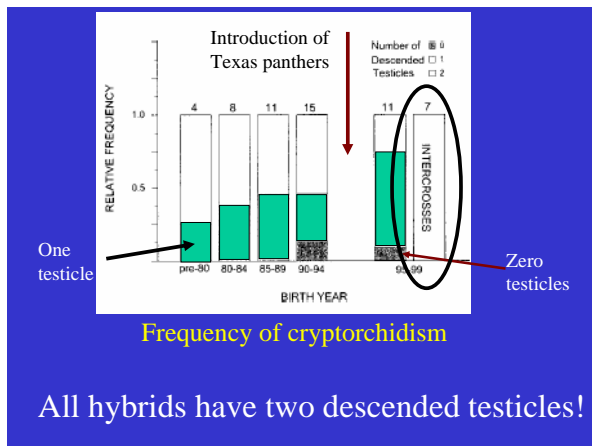
Introduction of females

## CRYPTORCHIDISM IN FLORIDA PANTHERS: PREVALENCE, FEATURES, AND INFLUENCE OF GENETIC RESTORATION

Kristin G. Mansfield<sup>1,2</sup> and E. Darrell Land<sup>1,3</sup>

<sup>1</sup> Florida Fish and Wildlife Conservation Commission, 566 Commercial Boulevard, Naples, Florida 34104, USA  
<sup>2</sup> Current address: Washington Department of Fish and Wildlife, 8702 N. Division Street, Spokane, Washington 99218-1199, USA





VORTEX:

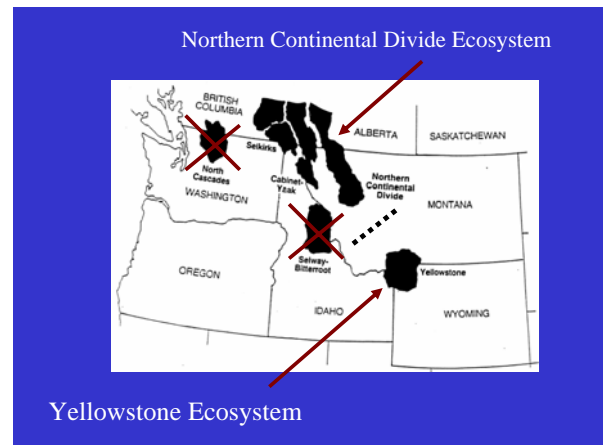
Population Viability Analysis (PVA)

Bob Lacy, CBSG

Society For Conservation Biology Annual Meeting

Grizzly Bear  
*Ursus arctos horribilis*

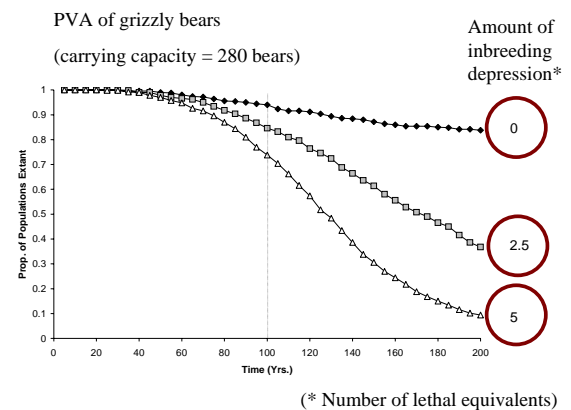
Mark Shaffer, Duke University



Approximately 350 grizzly bears in Yellowstone Ecosystem (YSE). Completely isolated from other grizzly bear populations.

(1) Should they be protected under US Endangered Species Act? That is, are they likely to go extinct?

(2) Should bears be translocated from Northern Continental Divide Ecosystem into YSE to reduce effects of inbreeding depression?





Grizzly Bear Artificial-Insemination Team, Montana

## GENETICS AND POPULATION VIABILITY

(1) Inbreeding depression

### *Beyond Inbreeding Depression*

(2) Loss of genetic and phenotypic variability

(3) Loss of evolutionary potential

(4) Effects of mtDNA

(5) Mutational meltdown

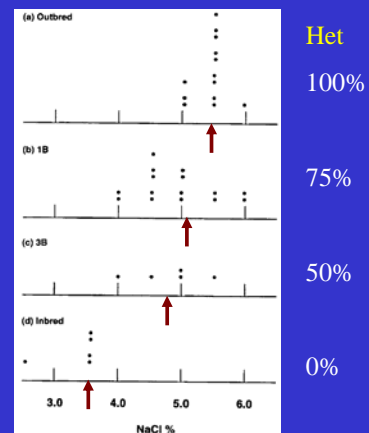
The last Illinois population of the lakeside daisy (*Hymenoxys acaulis* var. *glabra*) was effectively extinct even though it consisted of approximately 30 individuals because all plants belonged to the same mating type (Demauro 1993).



Response to  
selection for  
increasing  
NaCl

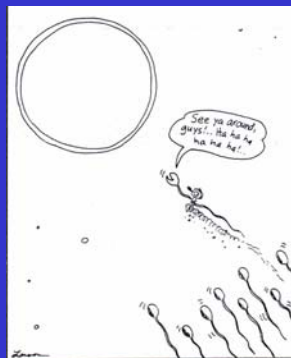
*Drosophila*

Frankham et  
al. (1999)



## mtDNA and Male Fertility

Sperm are motile and powered by mitochondria; even small reduction in power may reduce sperm motility and reduce fertility.

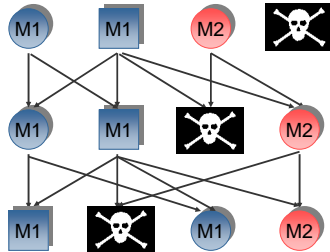


However, only mitochondrial mutations that reduce metabolic flux **more** than 20% have detectable clinical phenotypic effect.

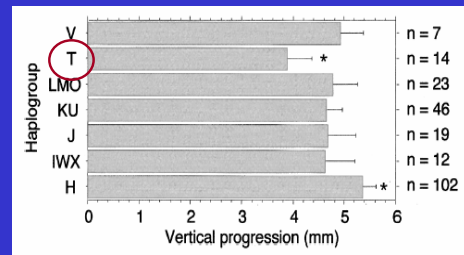
**But, .....**



However, mtDNA mutations that affect only males will NOT be affected by natural selection because genes not transmitted to progeny!



## Sperm Races (capillary tube for 30 minutes)



Vertical progression least for *T* genetic type found in sterile males.

## mtDNA & Population Viability

- Genotypes with slightly deleterious effects could contribute to the genetic load of small populations
- $N_e$  of mtDNA generally 25% that of nuclear genes
- Thus, mtDNA much more sensitive to population bottlenecks

Actions taken to reduce effects of inbreeding depression may not reduce genetic load due to mtDNA.

Translocation of only males into population will increase nuclear heterozygosity, but will not reduce genetic load due to mtDNA.

## GENETICS AND POPULATION VIABILITY

- (1) Inbreeding depression
- (2) Loss of genetic and phenotypic variability
- (3) Loss of evolutionary potential
- (4) Effects of mtDNA
- (5) **Mutational meltdown**

## Natural selection in small populations

Natural selection vs. genetic drift

Natural selection is not effective in small populations because random changes caused by drift can swamp effects of increased fitness.

If  $N_e s < 1$  then drift “wins”.

## Directional Selection & Drift

Accumulation of harmful mutations  
“mutational meltdown”

How large do populations have to be  
to ensure their long-term persistence?

How large do populations have to be  
to maintain sufficient genetic  
variation to adapt to changing  
environmental conditions?

$$N_e = 500 \text{ or } 5,000?$$

A PREVIEW: How large is large enough?

As a general rule, an  $N_e$  of 50 is necessary in the short-term to prevent immediate harmful effects of inbreeding, and an  $N_e$  of about 500 is necessary to retain enough genetic variation in order to maintain long-term evolutionary potential.

50/500 Rule

(Somewhat controversial)